

SOME OBSERVATIONS ON THE GENUS *TECTOCEPHEUS*

BY

P. W. MURPHY and M. JALIL

*School of Agriculture, University of Nottingham,
Sutton Bonington, Loughborough, Leicestershire, England*

Tectocephus velatus (Mich.) *s. lat.* is one of the commonest oribatid mites occurring in the soil. It is considered to be a eurytopic species and has been recorded from numerous habitats including moss cushions, grassland and woodland. It probably occurs in greatest numbers in drier situations such as moss on the surface of out-cropping rocks, and the results of WOOD's (1963) survey of moss habitats at Malham, Yorkshire are in agreement with this observation. It is a somewhat variable species and a number of these variants have been given specific status (KNÜLLE, 1954) on the basis of differences in the shape of the lamellae and associated structures. The primary object of the investigations reported here was to study the *T. velatus* complex, and to see if there was any correlation with site conditions. At first sight it would appear unlikely that such an ubiquitous species could be of value in differentiating sites but DAVIS (1961), in his study of grassland, found that this species had considerable discriminatory value when considered together with other members of the Acari and Collembola. The present account is a brief summary of certain aspects of the biology including the life cycle and periodicity of feeding of *T. velatus* and the closely related *T. sarekensis* Trägårdh. A more detailed account of these investigations will be published elsewhere.

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The genus contains some 11 species (KNÜLLE, 1954; BALOGH, 1958; VANĚK, 1960). *Tectocephus velatus* s. str., its best known member, is a small mite (length, 304 μ ; width, 180 μ) with well developed lamellae, and cusps having somewhat conical apices (Figure 1, A). The lamellar hairs, which normally lie just in front of the gnathosoma are curved, and there is a thin but distinct translamella. *Tectocephus sarekensis* is a slightly larger mite (length, 322 μ ; width, 197 μ), the cusps are somewhat broader (Figure 1, B) and have well rounded inner margins. The lamellar hairs appear stiffer and do not curve inwards to the same extent. Behind the translamellar region there is a rectangular area covered with grooves which are longitudinally directed but somewhat irregular. To distinguish these two mites it

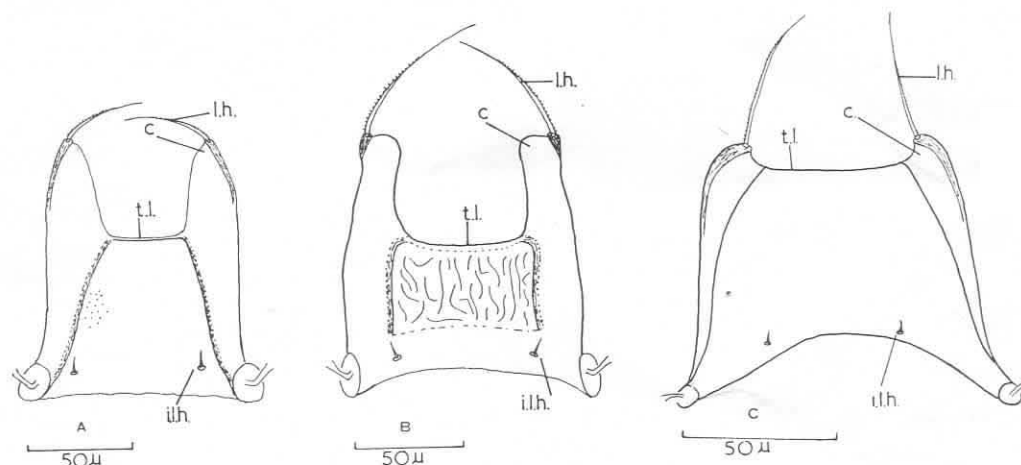


FIG. 1. — The lamellae and associated structures of the propodosoma of *Tectocephus velatus* (Mich.) (A), *T. sarekensis* Trägårdh (B) and *Tectocephus* sp. (C) : c., cusp; i.l.h., interlamellar hair; l.h., lamellar hair; t.l., translamella.

is essential to remove the gnathosoma and it is better to examine without a cover glass as the weight of the latter may cause distortion of the cusps. We have found no evidence to suggest that the immature stages of these two species differ morphologically, and in the account of the life cycle that follows they will be referred to as *T. velatus*. Apart from a single record of 3 specimens of an unidentified *Tectocephus* sp. (Figure 1, C) from moss (Malham, Yorkshire) we have not found any of the remaining 9 species of the genus.

LIFE CYCLE IN THE LABORATORY

T. velatus probably reproduces parthenogenetically under natural conditions, and certainly can do so in the laboratory. Many specimens have been examined but no males have been identified. In laboratory studies, the life cycle of a mixed

population of *T. velatus* and *T. sarekensis* took 102 (S.E. ± 7) days from the time of egg deposition to adult emergence (Table 1) when cultured in isolation at a temperature of 25°C in glass vessels with plaster of Paris; the food supplied consisted of skeletonized leaves taken from the litter layer of broadleaved woodland. About a third of this time was spent in pre-ecdysial quiescence (Table 1).

TABLE 1. — Duration of life cycle of *Tectocephus velatus* and *T. sarekensis* when cultured in the laboratory at 25°C (experiment commenced 27th July, 1961)

Stage	Total number of individuals	Mean duration (days)	Pre-ecdysial quiescent stage * (days)	Mortality (%)
† Egg	5	13	—	0
Larva	14	17	7	36
Protonymph	9	18	7	0
Deutonymph	9	19	9	11
Tritonymph	8	35	11	37

* Determined in separate experiment at 20°C.

† Data obtained from separate experiment (2nd February, 1962).

The eggs are extremely small (*ca.* 100 μ diameter) and usually round in shape. Of the 14 larvae reared in this experiment, only 5 survived to the adult stage (Table 1). Three of these adults were identified as *T. velatus* and two as *T. sarekensis*. Adults of both mites were also obtained by culturing tritonymphs collected from woodland litter. There was a marked pre-ecdysial resting period preceding the emergence of each stage (Table 1). The time taken for the moulting process, which is included in the quiescent period, was some 8-10 hours. Three adults (two *T. velatus* and one *T. sarekensis*) produced viable eggs without having come into contact with other mites at any stage during their life cycle.

LIFE CYCLE IN THE FIELD

A monthly sampling was made during the period July, 1961 to June, 1962 in Domleo's Spinney at the School of Agriculture to determine the numbers of immature stages, and adults of the two mites during the course of the year. The sampling area was a square plot (6.1-m sides) in one corner of a narrow strip (*ca.* 55 m wide) of mixed woodland. The tree species occurring in the woodland include oak and Sycamore with fairly rich shrub and ground layers. The soil is a glacial sandy drift with some gravel. The L + F layer was 3-6 cm deep; no H layer was present in the sampling area. Three sampling units (*ca.* 5 cm *d*;

area *ca.* 19.5 cm²) were taken on the same day of each month. A block method was used for sample removal and, after separation of L + F material (extracted in 2-cm layers), each core was subdivided into 2-cm layers for extraction in a split-funnel extractor (MURPHY, 1962).

TABLE 2. — Total and mean numbers of adults and immature stages of *Tectocephus* from monthly samplings of mixed woodland from July, 1961 to June, 1962
(Total and mean of 36 sampling units (*d* 5 cm; area *ca.* 19.5 cm²; 3 units/month)

Stage	Total number	Mean number/sampling unit	Vertical distribution (%)			Individuals with food present	
			L + F	0-2 cm	2-4 cm	Number (%)	Months present (number)
Adult	814	23	80.8	17.6	1.5	17	8
<i>T. velatus</i>	459	13	87.2	11.3	1.3		
<i>T. sarekensis</i>	355	10	72.7	25.6	1.7		
Tritonymph	955	27	82.4	16.9	0.7	30	10
Deutonymph	406	11	85.5	13.3	1.2	22	11
Protonymph	150	4	88.7	8.7	2.6	20	6
Larva	286	8	89.2	9.1	1.7	21	7

The total and mean numbers of individuals extracted are given in Table 2. The low numbers in the January sampling (Figure 2) may be due to the fact that the units were taken from frozen ground, and extraction may be less efficient under these conditions. The vast majority of the population occurred in the L + F and the 0-2 cm layer of the mineral soil (Table 2). Almost 1,000 tritonymphs were obtained, and this might be expected in view of the long time spent in this stage in laboratory culture (35 days), a period which may well be longer under natural conditions. The low number of larvae recovered may be due to the relatively short duration of this stage but the small number of protonymphs is a puzzling feature. One possibility is that the funnel method is less suitable for extracting certain stages. There are two peaks of larval numbers, in March and July respectively (Figure 2). Large numbers of tritonymphs are present in October — November, February — April, and a lesser peak occurs in June. These are followed by an increase in number of adults in November — December, February — April and June. The seasonal distribution in peak numbers of larvae and adults is in general agreement with the results of a number of surveys (cf. HAARLØV, 1960). Apart from the high number of deutonymphs in December, the remaining data are not very helpful.

These results would suggest the occurrence of at least two generations during

the course of the year, the first represented by high larval numbers in March, becoming adults (?) during the summer months. Eggs produced by these adults could give rise to the July larvae. In the second cycle larvae appear in July and become adults (?) in November—December. These may provide the reproductive source for the March generation. The long period with high numbers of tritonymphs and adults occurring in spring might be due to the presence of a mixed population of overwintering deutonymphs and tritonymphs, some of which may stem from larvae hatching in November—December, and some from the July

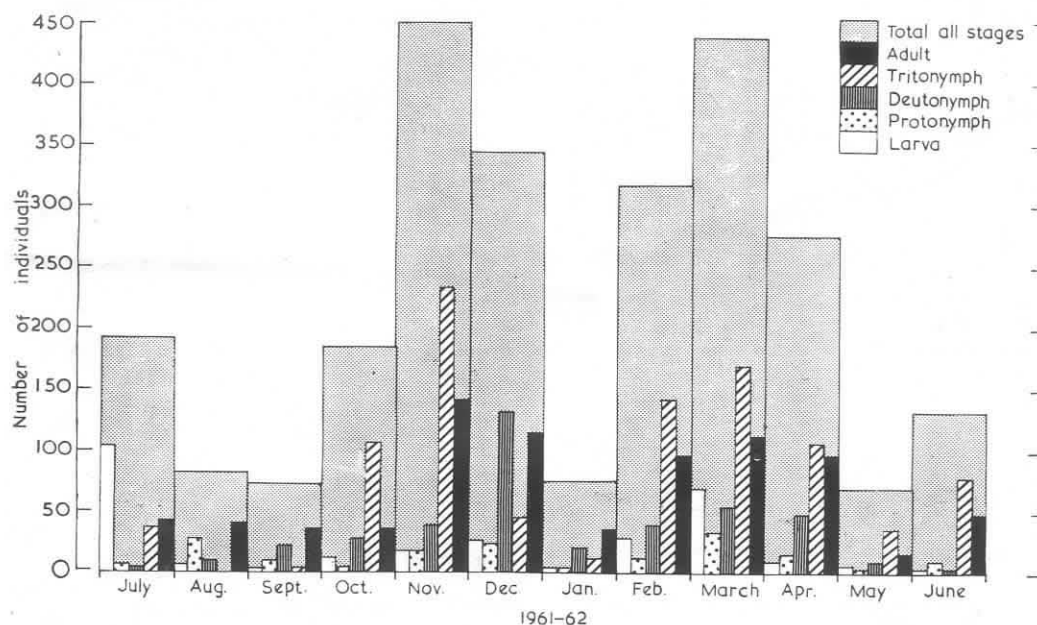


FIG. 2. — Total numbers of adults and immature stages of *Tectocephus* spp. obtained from 12 monthly samplings (3 sampling units/month) in mixed broadleaved woodland.

generation. There is a hint that not all members of the March generation become adult by July, and it is possible that these are responsible for the November—December larvae. There is some support for the two cycles outlined when the results of the gut-content examination are considered (Figure 3). The situation is complicated by a residuum of reproduction (larvae were present on all sampling dates) which appears to occur sporadically throughout the year, and the above hypothesis must be regarded as tentative until more information is available. However the presence of two generations in the year is supported by the results of other surveys (HAARLØV, 1960).

The presence or absence of food particles in the midgut was determined by microscopic examination of lactic acid mounts. No dissections were made and the presence of a compact food bolus in the form of a pellet was disregarded. It was

not possible to identify the food source. About 30 per cent of the tritonymphs extracted showed evidence of the presence of food ; the figure for adults and other immature stages was 17-22 per cent (Table 2). These results suggest that the tritonymphs may be the most important stage from the point of view of soil processes.

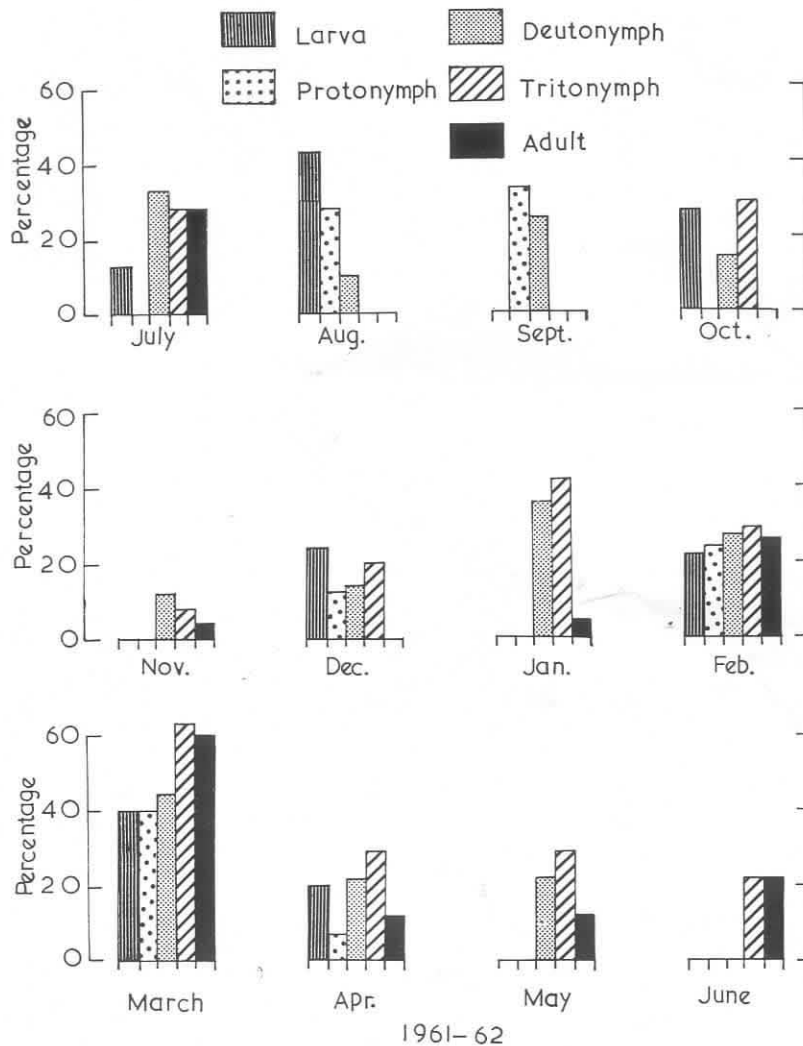


FIG. 3. — The proportions of adults and immature stages of *Tectocephus* spp. with food particles present in the midgut region expressed as a percentage of the total number of each stage obtained from monthly samplings of mixed broadleaf woodland.

The most active feeding period occurred in February—March (Figure 3) when all stages were well represented. In June—July there is a lesser rise in the percentage of adults with food present. In August the proportion of feeding larvae is high,

and the same applies in August and September in the case of protonymphs. The fairly high percentage of feeding deutonymphs and tritonymphs in January is of some interest.

RELATIVE ABUNDANCE OF *T. velatus* AND *T. sarekensis*

Each adult obtained in the field experiment was dissected to determine its identity using the criteria already mentioned. Both mites were present in each of the 12 samplings but *T. velatus* was dominant, the overall ratio being 1.3:1 (Table 2). There were, however, marked seasonal fluctuations in the relative abundance of the two mites (Figure 4). Thus *T. sarekensis* formed an increasing proportion of the adult population in the late autumn and became dominant in December—January. There was a further peak in April followed by a marked reduction in May—July. It is conceivable that a greater proportion of the early maturing individuals in each generation are *T. velatus*, and the possibility that the individuals of *T. sarekensis* represent later maturing individuals which have passed through some form of diapause as juveniles will have to be considered in future investigations. These fluctuations do not appear to be associated with particular habitats as a similar trend is apparent in the numbers obtained from moss cushions (sites I and II), a cliff-ledge soil (site III, mull-like rendzina) at Malham, and a miscellaneous series of sites at Sutton Bonington (Figure 4, A-F).

There was some difference in the vertical distribution of *T. velatus* and *T. sarekensis*. About 25 per cent of the latter were recovered from the first 2 cm of the mineral soil in contrast to the 11 per cent of *T. velatus* (Table 2). However appreciable numbers occurred in the 0-2 cm zone only during the November—February period, and for much of this time *T. sarekensis* was the dominant member. We do not know whether the morphological differences between these mites have functional advantages at different periods of the year. Indeed, as far as we are aware, the function of the lamellae is not known. One striking feature when *T. velatus*, *T. sarekensis* and *Tectocephus* sp. are compared is the orientation of the lamellar hairs (Figure 1). In the first they are markedly curved and lie close to the gnathosoma; in the second they are less closely in contact with the gnathosoma; and in the third they are almost straight and are directed forwards.

MORTALITY OF ADULTS AND IMMATURE STAGES IN DESICCATING CONDITIONS

In view of HAARLØV's (1942) observation of differences in morphology of individuals of *Tectocephus* collected from dry and wet places it was decided to carry out a laboratory experiment to determine the effect of desiccation on *T. velatus* and *T. sarekensis*. And, in view of the uncertainty concerning the reliability of the funnel method for extracting immature stages, it was decided to include these as desiccation of the sample material is usually considered the main stimulus for movement out of the sample. The method used was to desiccate the mites in micro-

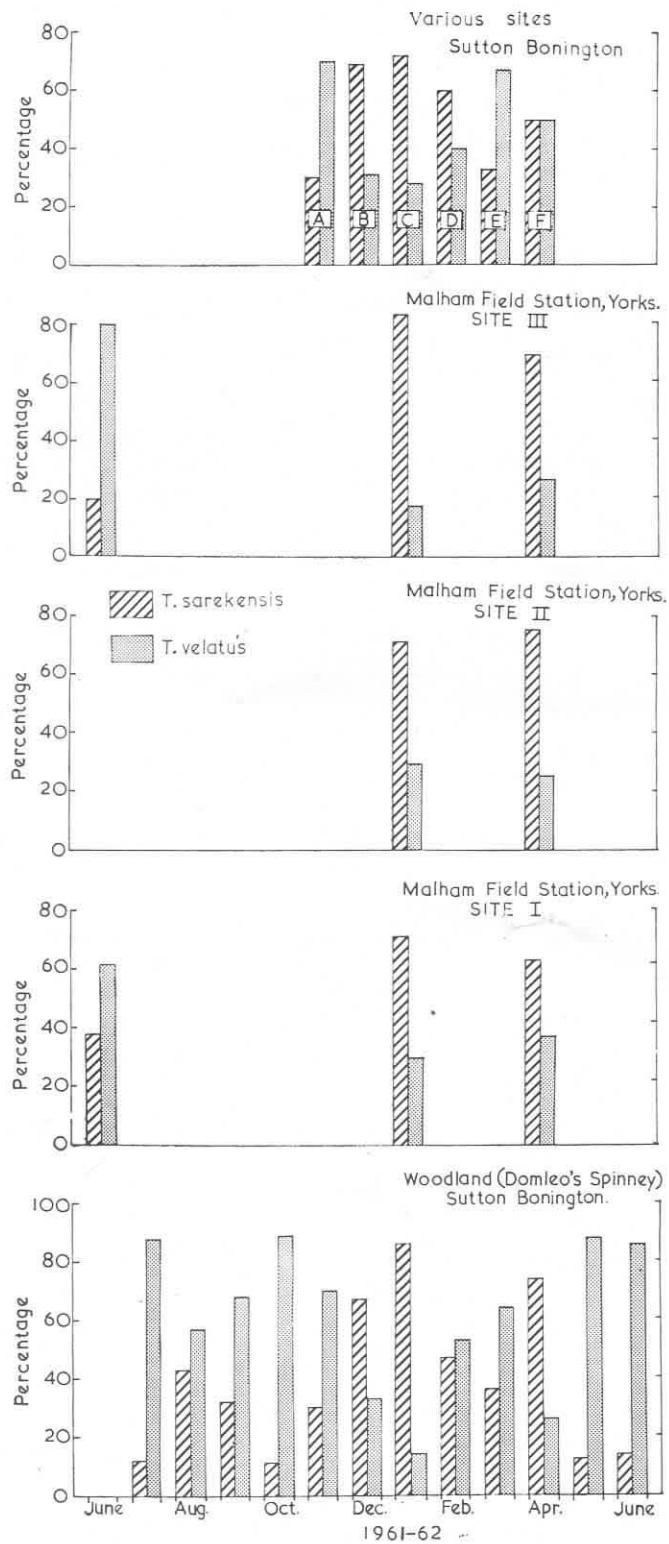


FIG. 4. — Comparison of seasonal changes in relative abundance of adults of *Tectocephus velatus* and *T. sarekensis* in woodland (Domleo's Spinney) and a number of other sites (Malham, Yorks. and Sutton Bonington). Site I, *Camptothecium* moss and *Tortella* cushion *rendzina* (Site II) on limestone boulders; Site III, cliff-ledge soil; A, B and F, grassland; C and E, woodland; D, compost.

desiccators using a bioassay procedure similar to that employed in toxicological studies. Twenty to fifty mites were exposed to each of 5 treatments in terms of hours' exposure to desiccant (phosphorus pentoxide) at a temperature of 15°C. The number of dead mites was determined 6 hours after the treatment had been completed. All mites used were obtained from the field. Using probit analysis the time required to kill 50 per cent of the population was determined, and this can be taken as the lethal dosage for an average individual. The results are presented in summary form in Figure 5. Differences in the 5 per cent fiducial limits in the case of adults appear to be related in the main to the size of sample dosed.

As one would expect, the larva with an L.D. 50 of *ca.* 2.5 hours is the most susceptible stage. There is a gradual decrease in susceptibility until the adult stage where the L.D. 50 is about 4 hours but the results for the tritonymphs (L.D. 50 approaching 5 hours) are somewhat anomalous. Three assays were made of adults collected from Domleo's Spinney (October to December, 1962). The results of each of these assays are given collectively as *Tectocephus*, and separately as *T. velatus* and *T. sarekensis*. This has been necessary as it was not possible to determine the numbers of the two mites present until the assay had been completed. The desiccation experiment was repeated in January, 1963 with adults collected from moss cushions at Malham, and grassland at Sutton Bonington. In most cases *T. sarekensis* appears to be slightly more resistant than *T. velatus* but the differences are small. There appears to be no consistent trend when the three sites are compared.

This attempt to obtain an estimate of ecological valency in terms of desiccation has proved inconclusive. It may be that the effect of desiccation *per se* is of small importance or that its effect as determined here is too crude a measure to assess the effect of moisture conditions in the natural environment. The effects of different moisture regimes may be extremely complex, and interactions with other environmental components and indeed with the physiological state of the animal may further increase the complexity of the relationship.

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SUMMARY

Tectocephus velatus (Mich.) and *T. sarekensis* Trägårdh have been found to be common cohabitants of woodland and grassland soil and moss cushions in England. Reproduction is parthenogenetic and the immature stages of the two species do not appear to differ morphologically. The life cycle from egg deposition to adult emergence is about 102 days at 25°C. The results of monthly samplings in mixed deciduous woodland suggest that two generations occur during the year. Thirty per cent of the tritonymphs recovered

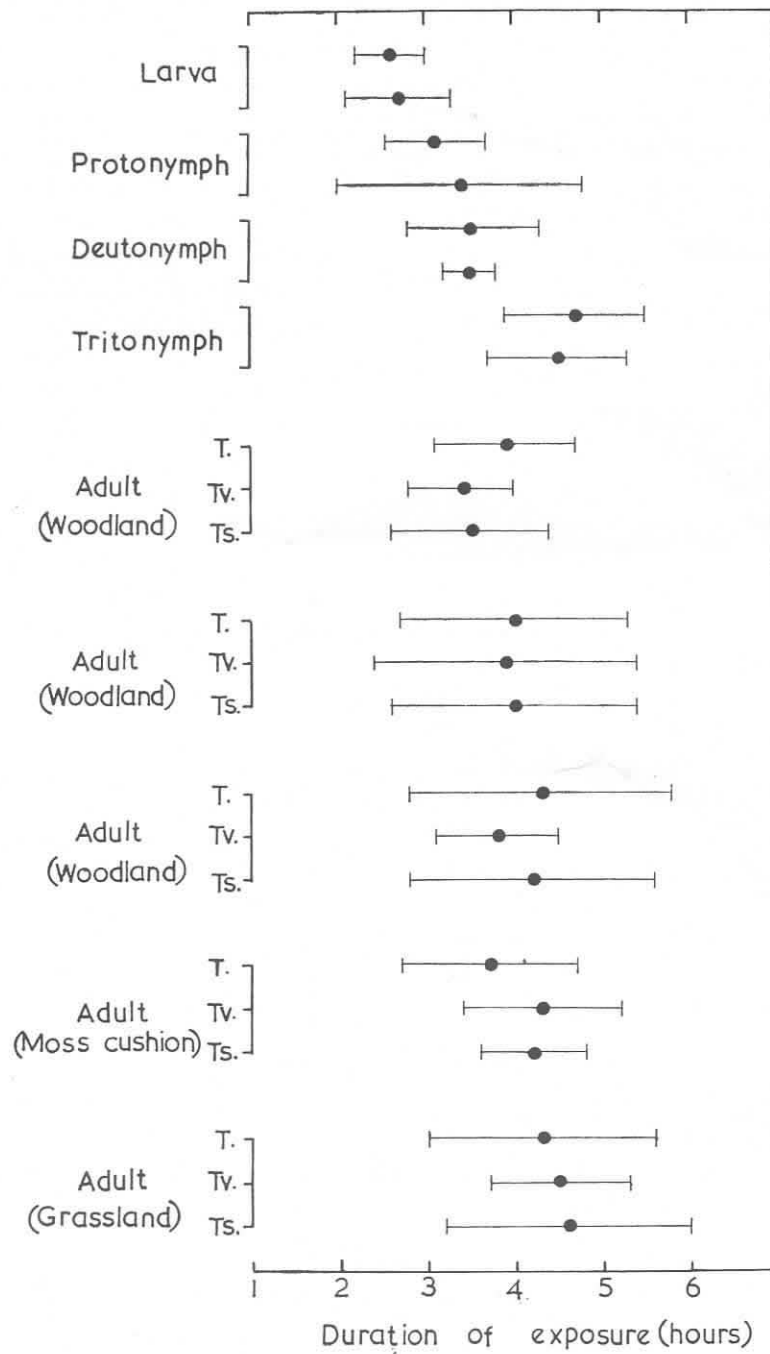


FIG. 5. — The mortality of immature stages and adults (*Tectocephus velatus* (Tv.) and *T. sarekensis* (Ts.)) in desiccating conditions (r.h. 0 per cent; temperature 15°C), expressed as L.D. 50 (●) in hours and 5 per cent fiducial limits (—).

had food content in their gut compared with 17-22 per cent of the remaining stages. The most active feeding period for all stages was February and March. *T. velatus* was the dominant species the ratio being 1.3 : 1 but there were marked seasonal fluctuations in relative abundance, and *T. sarekensis* was dominant in December, January and April. There was a marked similarity in the seasonal pattern of relative abundance in all sites. The effect of desiccation at 15°C was determined for all stages of the life cycle.

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